# FLUORIDE GEOCHEMISTRY OF GROUNDWATER IN NALHATI-1 BLOCK OF THE BIRBHUM DISTRICT, WEST BENGAL, INDIA

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**Summary: The concentration of fluoride ion (F) in groundwater samples from different sites in Nalhati-1 block of the Birbhum district, West Bengal, was determined by SPADNS colorimetric analysis. Most of the F levels were within permissible limits, whereas a significantly higher concentration of 1.95 mg/L was found in artesian well samples of Nasipur village. The F in groundwater appears to be controlled by the distribution of $Ca^{2+}$ and to some extent $SO_4^{2-}$, ionic strength, and the presence of complex ions. From correlation coefficient analysis, F was found to be inversely related to $Ca^{2+}$ and positively related to $Na^+$. Basaltic rock and water interaction with it may be responsible for the increased F in the artesian well samples from the study area.**

Keywords: Artesian well water; Basaltic rock; Birbhum district, India; Groundwater fluoride; Nalhati-1 block; West Bengal, India.

## INTRODUCTION

Endemic fluorosis is present in at least 20 states of India, affecting more than 65 million people including 6 million children. Fluoride ion (F) concentrations in India's groundwater vary widely, ranging from 0.01 mg/L to 48 mg/L. The amount of F occurring naturally in groundwater is governed principally by climate, composition of the host rock, and hydrogeology. Areas with a semi-arid climate, crystalline rocks, and alkaline soils are mainly affected.[1] In general, the presence of F may be due to low-level basaltic volcanic activity.[2] The occurrence of elevated F concentrations in groundwater (> 1.5 mg/L) in the villages of Singpur and Sagaragan in the Nayagarh district of Orissa in relation to nearby hot spring water (> 10 mg/L) has also reported.[3]

The present study area lies between 24°32′30″–24°35′N and 87°01′–87°05′25″E. It is the Nalhati-1 block of the extreme western part of the Birbhum district, West Bengal. Geologically, the area consists of fine grained, hard, and compact basaltic rocks. These rocks possess negligible primary porosity but acquire secondary porosity by fracturing and weathering. The topography is moderately hilly with very sparse vegetation. Our aim was to do a chemical characterization of groundwater bodies in the area, with special attention to F contamination and to highlight the probable causes of contamination.

## MATERIALS AND METHODS

In addition to F, other parameters such as pH and TH (total hardness), important cations such as $Ca^{2+}$, $Mg^{2+}$, $Na^+$, and $K^+$, and anions such as $Cl^-$ and $SO_4^{2-}$ were determined (Jan to Feb, 2006) by standard methods.[4,5] F concentration was measured by the SPADNS colorimetric method. For comparative evaluation, correlation was attempted between various parameters.

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## RESULTS AND DISCUSSION

The analytical results are shown in Table 1.

**Table 1.** Analytical results of Nalhati-1 block groundwater samples (Values are in mg/L except pH; maximum and minimum values are expressed as bold underlined and bold italic, respectively; TH = total hardness, D = dugwell, T = tubewell, AW = artesian well)

| Sample No. | pH | TH | $Ca^{2+}$ | $Mg^{2+}$ | $Na^{+}$ | $K^{+}$ | $SO_4^{2-}$ | $F^{-}$ | $Cl^{-}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1D | 8.21 | 140 | 33 | 26 | 3 | 1 | 14 | 0.02 | 130 |
| 2T | 7.46 | 200 | 59 | 34 | 55 | 9 | 5 | 0.16 | 140 |
| 3T | 8.43 | 140 | 50 | 21 | 2 | ***0.3*** | 8 | 0.19 | 40 |
| 4T | 8.26 | 140 | 42 | 24 | 2 | 0.6 | 1 | 0.09 | 30 |
| 5T | 8.48 | 160 | 25 | 33 | 2 | 0.9 | 2 | 0.14 | 60 |
| 6D | 7.91 | 260 | 84 | 42 | 6 | 9 | 41 | 0.01 | 150 |
| 7T | 8.47 | 120 | 25 | 23 | 39 | 5 | 2 | 0.24 | 50 |
| 8T | 8.43 | 160 | 33 | 30 | 30 | 4 | 2 | 0.23 | 50 |
| 9T | 8.09 | 900 | 126 | 188 | 10 | 1 | 128 | 0.34 | 479 |
| 10D | 8.51 | 300 | 76 | 54 | 2 | 2 | 25 | ***0.006*** | 160 |
| 11T | 8.54 | 160 | 33 | 30 | 37 | 6 | 8 | 0.28 | 40 |
| 12D | 8.51 | 340 | 92 | 60 | 2 | 2 | 25 | 0.10 | 194 |
| 13D | 7.67 | 660 | 176 | 117 | **940** | 130 | 107 | 0.14 | 439 |
| 14D | **11.26** | 740 | 151 | 143 | 180 | 180 | 147 | 0.54 | 559 |
| 15T | 7.92 | 480 | 126 | 86 | 930 | **230** | 94 | 0.41 | 379 |
| 16AW | 8.23 | ***20*** | ***4*** | ***3*** | 14 | 0.6 | ***0.17*** | **1.95** | 160 |
| 17T | 7.41 | **2000** | **622** | **336** | 889 | 10 | 5 | 0.32 | **1539** |
| 18T | 8.30 | 260 | 67 | 47 | 6 | 1 | **152** | 0.10 | 210 |
| 19T | 7.29 | 200 | 50 | 36 | 3 | 0.5 | 6 | 0.23 | 30 |
| 20T | 7.29 | 220 | 59 | 39 | 3 | 0.6 | 1 | 0.27 | ***30*** |
| 21D | 7.50 | 1040 | 336 | 171 | 11 | 2 | 8 | 0.06 | 839 |
| 22T | ***7.05*** | 200 | 75 | 30 | 31 | 4 | 18 | 0.02 | 130 |
| 23T | 7.21 | 240 | 75 | 40 | ***1*** | 0.3 | 2 | 0.27 | 140 |
| 24T | 7.43 | 880 | 235 | 157 | 3 | 1 | 107 | 0.25 | 330 |
| 25T | 7.60 | 1040 | 235 | 196 | 15 | 1 | 128 | 0.34 | 469 |

A correlation matrix is shown in Table 2.

**Table 2.** Correlation coefficients of Nalhati-1 block groundwater samples (TH = total hardness)

| | pH | TH | $Ca^{2+}$ | $Mg^{2+}$ | $Na^{+}$ | $K^{+}$ | $SO_4^{2-}$ | $F^{-}$ | $Cl^{-}$ |
|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | |
| TH | -0.113 | 1 | | | | | | | |
| $Ca^{2+}$ | -0.207 | 0.965 | 1 | | | | | | |
| $Mg^{2+}$ | -0.073 | 0.994 | 0.932 | 1 | | | | | |
| $Na^{+}$ | -0.088 | 0.507 | 0.538 | 0.484 | 1 | | | | |
| $K^{+}$ | 0.401 | 0.152 | 0.102 | 0.168 | 0.690 | 1 | | | |
| $SO_4^{2-}$ | 0.301 | 0.356 | 0.185 | 0.419 | 0.236 | 0.488 | 1 | | |
| $F^{-}$ | 0.164 | -0.048 | -0.078 | -0.036 | 0.040 | 0.110 | -0.004 | 1 | |
| $Cl^{-}$ | -0.052 | 0.952 | 0.960 | 0.930 | 0.583 | 0.216 | 0.250 | 0.046 | 1 |

In the area of the present study F concentrations in the groundwater were found to vary from 0.006 to 1.95 mg/L. The positive correlation of pH with F suggests that pH is important in determining F in groundwater, in agreement with earlier observations.[6] As found previously by others,[1] elevated F in the groundwater was generally associated with low $Ca^{2+}$. On the other hand, higher F was associated with high $Na^{+}$ and low $SO_4^{2-}$. The correlation of F with pH, $Mg^{2+}$, and $Ca^{2+}$ is significant at $p \leq 0.05$ (t-test). Correlations with other parameters, however, are not statistically significant.

Except for the 1.95 mg F/L in the artesian well of Nasipur village, most of the groundwater F concentrations were not exceptionally high. The source of this F contamination in ground water at Nasipur may be due to the presence of intertrappean sedimentary beds that were originally enriched in F at the time of deposition and subsequently became soluble in entrapped water by favourable physico-chemical conditions. Otherwise, entrapped water may leach and dissolve locally concentrated pockets of highly soluble villiaumite (NaF) within the volcanic trap rock during its journey from a secondary aquifer to the surface.

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